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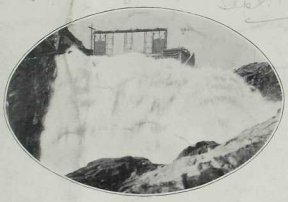
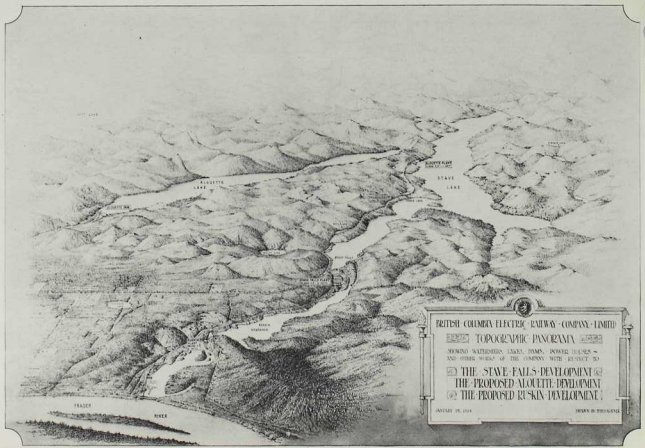
The Stave Falls Power Development

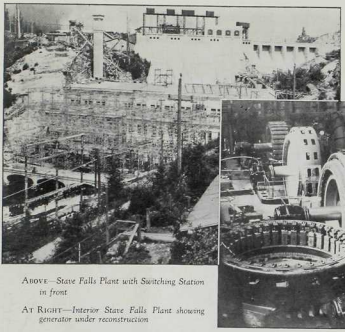
COMPLETED
SEPTEMBER
1925



BRITISH COLUMBIA
ELECTRIC RAILWAY COMPANY
VANCOUVER, B.C.


BRITISH COLUMBIA ELECTRIC RAILWAY COMPANY LIMITED
TOPOGRAPHIC PANORAMA
SHOWING WATERSHEDS LAKES DAMS POWER HOUSES
AND OTHER WORKS OF THE COMPANY WITH REFERENCE TO
1 THE STAVE FALLS DEVELOPMENT
2 THE PROPOSED ALOUETTE DEVELOPMENT
3 THE PROPOSED RUSKIN DEVELOPMENT
ALOUETTE LAKE
STAVE LAKE
FRASER RIVER

Bird's-eye view of the Alouette-Stave Development and the proposed Ruskin Development



Above—*Stave Falls Plant with Switching Station in front*

At Right—*Interior Stave Falls Plant showing generator under reconstruction*

The STAVE FALLS POWER DEVELOPMENT

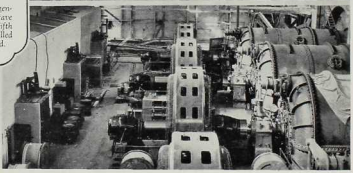
THE completion of the Stave Falls power plant marks the consummation of construction work which has been carried on by the British Columbia Electric Railway Company continuously for four years, and on which more than $3,725,000 has been expended.

The original Stave Falls power development was started in the winter of 1909-1910 by the Western Canada Power Company, control of which was acquired by the British Columbia Electric Railway Company at the end of 1920. At that time the installation consisted of three units with a total capacity of 35,500 horse power. The water storage in Stave Lake was 171,000 acre feet and the plant was capable of an annual output of approximately 150,000,000 kilowatt hours.

Due to the increased demand for electric current in Vancouver, New Westminster and the lower mainland, it was necessary to proceed with further developments and these having been completed, the Stave Falls plant now has a capacity of 87,500 horse power.

TOP: *Stave Falls power house as extended to house fifth unit.*

CENTRE: *Slab of concrete which forms the floor of the new $300,000 outdoor switching station.*



BOTTOM: *Four generators in Stave Falls plant. Fifth has been installed at extreme end.*

Stave Lake has a storage capacity of 471,000 acre feet, and the plant has an annual capacity of 250,000,000 kilowatt hours.

The steps taken in the development were as follows:

The installation of a fourth unit, completed in November, 1922.

The building of the Blind Slough dam and the raising of the Main and Intake dams.

The installation of a fifth unit and the rewinding of the other four units.

Related to the Stave development also is the Alouette development, which, when completed towards the end of 1926, will add 13,400 horse power to the system.

Raising the Dams

Construction work on the Blind Slough, Main and Intake dams was begun in April, 1922, and finished early in 1924. A quarter of a mile east of the main channel of Stave River and separated by a high rocky hill is a channel known as the Blind Slough. As this channel is some 20 feet higher than the main channel it did not, while water remained at the former level, function as an outlet, but was closed by log jams and beaver dams. When it was decided to raise the level of Stave Lake, a permanent dam was necessary at this point.

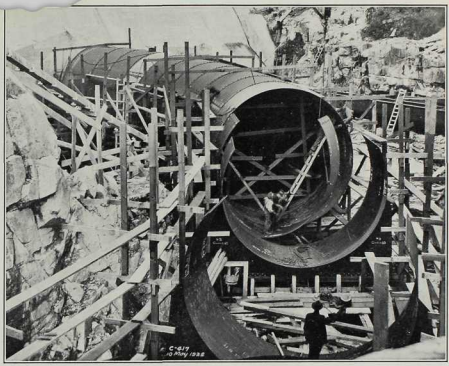
The Blind Slough dam is a solid concrete structure 640 feet in length and 60 feet deep at its lowest point. It carries the Dewdney trunk road to Mission. The Blind Slough dam is now used to take care of the flood discharge, the gates and stop logs being capable of discharging 96,000 second feet, which is 60 per cent. in excess of the maximum recorded flow.

The original Intake dam immediately above the power house was 160 feet in length, 40 feet in width at its crest, and 55 feet in height. It was constructed originally with the view of being heightened at a later date. Adjoining the intake dam was the former sluice dam through which the flood waters discharged.

Both of these dams were raised 25 feet. The work on the sluice dam consisted of filling in between the piers with concrete and raising the whole structure. In the Main dam, the tainter gates were replaced with roller gates, so that the large wells in the dam required by the tainter gates could be filled with concrete to give the necessary stability to the new structure.

A further work was the building of the west wing wall to prevent seepage through the gravel, sand and clay forming the bank at the west end of the dam.

Altogether 42,000 cubic yards of concrete were placed in the Blind Slough dam and the new portions of the Main, Intake and West Wing dams.



In building the great 324-foot penstock for operating the fifth unit, great concrete piers were constructed between the existing penstocks carrying the new pipe. Each saddle on which the penstock rested allowed for expansion and contraction with heat and cold.

The Fifth Unit

When the storage in Stave Lake was increased from 171,000 acre feet to 471,000 acre feet, it was found possible to increase the installation at the plant another unit of 17,500 horse power.

At this time the proposal to divert water from Alouette Lake by way of Stave Lake was approved and it was further decided to increase the capacity of the Stave Falls plant by rebuilding the existing four generators. Owing to the higher operating head, due to raising the level of Stave Lake 22 feet, the existing turbines were found capable of carrying a load considerably in excess of their normal rating, and by rewinding the generators the capacity of each machine was increased from 8,825 kilowatts to 13,125 kilowatts, or 17,500 horse power, equal to the fifth unit.

The penstock for the fifth unit has its intake in the Main dam and crosses the other four penstocks. It is 20 feet in diameter at the upper end and tapers to 13 feet at the butterfly valve at the power house wall. Its total length is 324 feet.

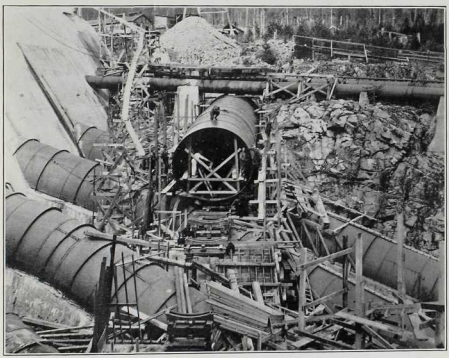
In order to provide accommodation for the fifth unit the power house was extended westward, 58,000 cubic yards of rock being excavated.

The building as finished measures 215 feet long and 100 feet wide.

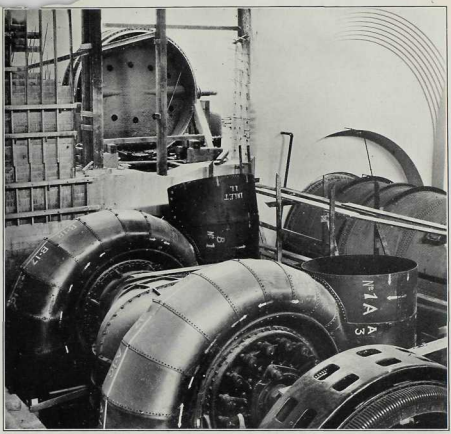
The installation of the fifth unit entailed some intricate engineering problems. It was necessary to bring the penstock over the existing four penstocks to reach the generator at the east end of the power house. This also necessitated a special design of intake for the turbine. In excavating for the power house extension, blasting took place only 25 feet from an operating generator.

Switching Equipment

The rebuilding of the existing four generators, together with the addition of the fifth unit, increased the capacity of the plant from 47,400 horse power to 87,500 horse power. This greatly increased capacity made necessary the installation of new switching



This shows No. 5 penstock threading its way under the exciter penstocks and over the four main penstocks to its place at the west end of the power house.



The fifth unit under construction. Owing to the position and the route followed by the penstock, a special type of pipe leading into the turbine had to be constructed. In the background will be seen the "butterfly valve," sixteen feet in diameter.

equipment to safely handle the load and provide for the desired continuity of service.

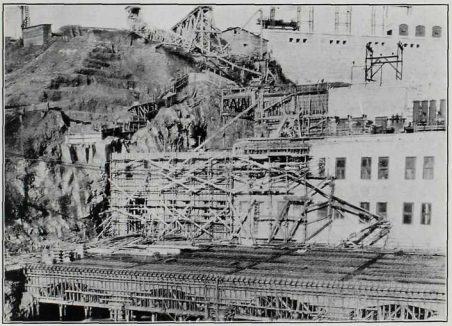
In the original plant all switches were installed in the power house building. Since that time, however, great developments have taken place in the design of electrical machinery, and it was found that all the adequate modern equipment required could not conveniently be housed indoors. It was decided therefore to purchase a high tension equipment of the outdoor type, and this is installed in an outdoor station immediately in front of the power house on the downstream side.

The substructure of this station consists of a reinforced concrete slab 160 feet long by 68 feet wide, supported on twelve concrete piers set in the tailrace. The superstructure of latticed steel towers

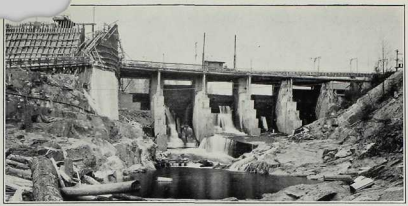
and girders is 153 feet long by 50 feet wide, the maximum height being 62 feet. Some 243,000 pounds of steel were required.

Electric current is generated at 4,400 volts in each of the five generators. It then passes from each generator through a low-tension oil switch situated on the main floor in front of each generator to a bank of three transformers where the current is stepped-up to the transmission voltage of 60,000. From the transformers it passes out of the power house to the outdoor station through to a high tension oil switch, then selectively through two sets of gang-operated disconnecting switches, which are manually operated by a lever at floor level, to either of two high-tension buses.

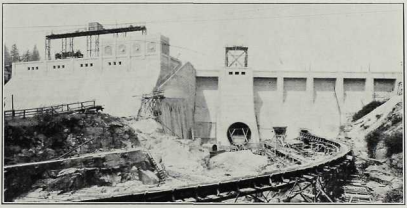
Feeding off the high tension buses are three transmission circuits. Two of these carry current to Horne-Payne receiving station, where they are tied in to the system feeding Greater Vancouver. These circuits, partly on account of the great amount of power handled and partly to provide for continuity of service, are each equipped with two oil switches, one of which is always kept in reserve. The third high tension circuit crosses the Fraser River and ties in with the Fraser Valley System at Matsqui sub-station.



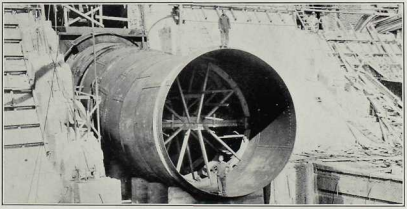
To extend the power house to permit installation of a fifth unit entailed cutting away the solid rock forming the western bank. In all 18,000 cubic yards of rock were removed. Blasting was carried on 25 feet from an operating generator.



Downstream view of sluice dam before reconstruction. This dam was filled in solidly as shown in the next picture and raised 25 feet. The Blind Slough dam is now used as the sluice dam.



The finished Intake and Main dams. Compare the picture with that immediately above. In the centre will be seen the opening for the fifth penstock and at the right temporary shingle-bolt flume.



The penstock for the fifth unit as it leaves the Main dam is 20 feet in diameter, afterwards tapering down to 13 feet 5 inches.

In addition to the circuits just mentioned, there feeds off the high-tension buses a circuit that runs back into the power house to a bank of transformers where the current is stepped down to 12,000 volts for local distribution and use. Provision is also made for a 60,000 volt line to tie in the Alouette generating station.

Transmission lines are provided with lightning arrester equipment to cut down to a minimum trouble caused by lightning discharges and surges, which act much the same as lightning.

All switches are electrically controlled from the main switchboard, which is situated on a gallery at the east end of the power house. On this board are also located the indicating and recording instruments for generating units and transmission circuits. Behind the main switchboard is an auxiliary board which contains the generating unit and transmission line protective relays and station service control apparatus. Beneath the switchboard gallery is a room where direct current for energizing the generators is centralized and distributed.

Alouette Development

Closely related to the Stave development, and now in process of construction, is the Alouette development. There are virtually two Alouette Lakes, formerly separated by a short, running stream. These lakes, some 25 miles east of Vancouver, lie contiguous to Stave Lake, and at the north end are separated from it by only some 3,600 feet.

The project consisted of damming the lakes and boring a tunnel through the mountain separating Alouette and Stave Lakes. At the mouth of this tunnel, owing to the difference of 140 feet between the levels of the two lakes, a power house will be built. The dam at the mouth of Alouette Lake will raise the water 45 feet.

The power plant will be automatic, operated from Stave Falls by means of throwing in the high-tension switches. It will be the largest single-unit automatic plant so far constructed and represents the latest in electrical engineering achievement.

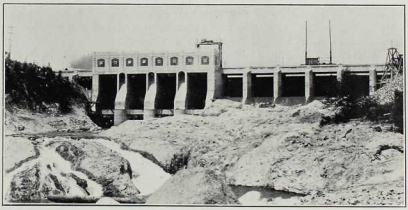
Water will thus flow successively through Alouette plant, Stave Falls plant and, at a later date, through the proposed plant at Ruskin.

The tunnel has been completed and water is flowing through it. Work is proceeding on the dam which will be completed this autumn. The power plant will probably be constructed in 1926.

The Alouette development will add 13,400 horse power and 57,400,000 kilowatt hours annually to the B.C. Electric system. The project will cost $2,300,000 to complete.

Old crib dam that was replaced with the Blind Slough dam.

The Blind Slough dam showing flood discharge through stop-log section.



The Blind Slough dam.

How a Power Plant is Operated

The operation of a power system is an intricate process which is difficult to explain without the use of technical terms.

It is carried out by a staff of shift operators located in the various generating and sub-stations, all of whom are working under the direction of a load despatcher, located at some central point, well equipped with communication with the different points of the power system. In the case of this Company's mainland power system, the load despatcher is located at the Main Street sub-station in Vancouver.

The load on the power system varies from hour to hour throughout the day, and generators are started up and shut down in the various power stations in accordance with the demand for the time being. On receiving instructions from the load despatcher to start up an additional generator, the operator on shift proceeds to do this by admitting water to the turbine by opening the gates controlling the flow water in the penstock. When the turbine and its generator reach the normal speed, and before any actual power load is taken up by this unit, the generator requires to be synchronized with the rest of the power system.

Synchronizing consists of tying the generator electrically to the bus-bars of the power plant through a suitable oil circuit breaker. As all the generators normally operate in unison with regard to the alternations of the electric current, the operation of synchronizing a generator requires considerable care, and for the purpose of carrying out this operation, special instruments are used at the switchboard which indicate to the operator the precise moment when the generator in question is in unison with the remainder of the system.

As soon as the generator has been synchronized, the unit is ready to assume its share of the system load, the proper share being proportioned by adjustments made on a governor which controls the turbine and the quantity of water which the unit requires for the electrical load. This governor is an automatic device which controls and maintains the speed of the turbine and generator constant at all loads within the capacity of the unit. If the electrical load on the generator increases, the governor actuates mechanisms on the turbine which admit additional water to take care of this increased load. On the other hand, if the electrical load on the generator is decreased, the governor acts in the opposite way and reduces the amount of water passing through the turbine. In this way, the various generating units maintain their proportionate share of the system load, and when the total load exceeds the combined capacity of the generators in service, an additional unit must be started up in the manner described.

The shutting down of a generator is accomplished by reducing the supply of water passing into the turbine until the unit is relieved

of its share of the electrical load, when the generator is simply separated from the station bus-bars by opening its oil circuit breaker.

Electrical currents are generated in the stationary portion, or armature, of the generator. This armature, which in the case of machines of the Stave Falls type is also known as the stator, consists of a number of insulated copper bars connected to each other and laid in slots in the iron body of the stator. The revolving portion, or rotor, is a system of magnets revolving on a shaft coupled directly to the main shaft of the turbine. The action of this magnet system on the copper conductors in the stator is to induce electric currents in the latter, which currents are conducted from the machine by means of cables attached to suitable terminals on the bottom portion. The magnets of the rotor portion are of the electro-magnet type which receive their magnetizing current from special generators known as exciters. This magnetizing current requires to be direct current, as distinct from alternating current generated by the main units. Two of the exciters in the Stave Falls plant are located at the east end of the generating room, each being driven by a separate turbine. A third exciter, connected to the fifth generating unit, is installed near the west end of the station.

* * * * *

The British Columbia Electric Railway Company's mainland system generated 300,500,000 kilowatt hours in 1924. In the last four years there has been an increase of 41 per cent. in power supplied this district. A study of the situation would indicate an annual cumulative increase in power load of 8 to 10 per cent. and a doubling of the power output every seven to nine years.

The present capacity of the mainland hydro-electric plants is as follows:

Lake Buntzen plants	146,000,000 kilowatt hours
Stave Falls plant	250,000,000 kilowatt hours
Alouette plant (under construction)	57,400,000 kilowatt hours
Total	453,400,000 kilowatt hours

At the present rate of growth, this capacity must be doubled by 1934. An expenditure of $25,000,000 in new plants, transmission lines, substations, etc., will therefore be necessary in that time, an annual expenditure of some $3,000,000.

THE STAVE FALLS POWER DEVELOPMENT

87,500 horse power

Total cost $15,000,000

Of this amount, $3,725,000 has been expended by the British Columbia Electric Railway Company since 1920.

ALOUETTE POWER DEVELOPMENT

13,400 horse power

Total cost when completed $2,300,000

On completion, the Alouette-Stave Development will have cost a total of $17,300,000.

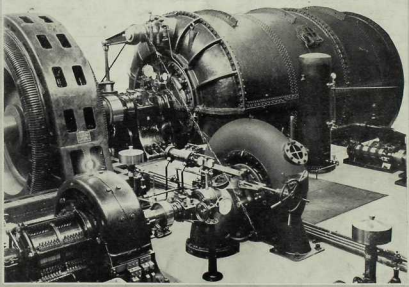
SUMMARY OF POWER DEVELOPMENT

Hydro-electric plants:	
Lake Buntzen No. 1	28,200 horse power
Lake Buntzen No. 2	35,800 horse power
Stave Falls	87,500 horse power
Alouette (under construction)	13,400 horse power
Jordan River (Vancouver Island)	21,500 horse power
Goldstream (Vancouver Island)	3,600 horse power
Total hydro-electric	190,000 horse power
Steam:	
Vancouver	16,800 horse power
Brentwood (Vancouver Island)	5,400 horse power
Total steam	22,200 horse power
Grand total	212,200 horse power

ELECTRICITY

Carrier of light and power
Devourer of time and space
Bearer of human speech over
land and sea
Greatest servant of man—
Itself unknown

—Inscription Union Station
Washington, D.C.



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